On a New Genus of Synascidians from Japan.

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With Plates XVII and XVIII.

The remarkable compound Ascidian which we[1] are about to describe was collected in quantity by one of us at Moroiso, a place which stands at the head of a small bay to the north of Misaki, some fifty miles south of Tokio. It was found in the months of July and August, hanging downwards from the lower surface of the shelving rocks between the tide-marks, and is therefore exposed at low water at certain times of the year. It was soon regarded as probably a new form, and such has since proved to be the case.

As will be seen below, the new genus belongs to the family of the Didemnidæ, and the name we propose for it is Sarcodidemnoides misakiense. It may be considered as standing in a similar relation to the genus Didemnoides that Sarcobotrylloides does to Botrylloides.

The following description will be found incomplete in one or two points, partly owing to the time of the year at which

[1] The study of this Ascidian colony was commenced by one of us at Misaki, continued by both of us in Freiburg-i.-Br., and concluded by the other of us at Plymouth and Naples.

the material was obtained (there being no male genital organ in any of the colonies examined), and partly owing to the fact that while the specimens which reached Europe were in a sufficiently good condition to establish the systematic position of the new genus, yet they were not suitable for a very minute examination, especially with regard to the details of budding. In spite of these gaps, the most serious of which is the failure to observe the testis and vas deferens, the general appearance of the colony is so singular and characteristic, and the canal system so interesting, that we thought it worth while to send in this account.

1. Manner of Growth and Outer Form.

On Pl. XVII is given a reproduction of a coloured drawing of a living colony according to the natural size, which was executed at the behest of one of us by a Japanese artist.

The portrait is singularly striking and accurate. The colour is a brilliant red, and the surface of the colony is smooth and glistening.

At the tips of the round knoll-like lobes, which are a very characteristic feature of the genus, are seen the small but distinct excurrent orifices. The lips of the pores are slightly raised above the level of the surrounding surface. The incurrent orifices are, of course, the mouths of the Ascidiozooids, but they are too small to be seen with the naked eye on a living colony, which, indeed, is not transparent.

The shape of a colony in the transverse direction is shown in fig. 2 on Pl. XVIII. From this figure we note the unusual circumstance that the base or surface of attachment is considerably narrower than the free portion.

According to the observations of one of us in Japan, the direction of the length of a colony is always parallel to the coast-line; and further, colonies growing end to end frequently undergo concrescence, and in this way produce a compound aggregation which often attains to a great length, namely, two or three feet.

This Didemnid presents a great contrast to most if not all

other Didemnids in the fact that its height or thickness in the vertical direction exceeds two- or three-fold the width, while in other forms the thickness or vertical height of a colony is usually very small. Our genus agrees with all other Didemnidæ in being sessile, but differs from most of them in not forming encrusting or straggling masses.

Beyond the characteristic lobes and the upraised margins of the excurrent orifices there are no processes of any kind on the external surface of the colony.

2. Canal-System.

The canal-system of the new genus bears a general resemblance to that found in other forms of the Didemnidæ, but in its extent and elaboration stands alone.

A schematic representation of the system of canals is given in fig. 1, while an actual transverse section is shown in fig. 2.

It will be at once evident that the canal-system consists of a peripheral portion and a central portion. The peripheral portion consists of much-branched canaliculi, whose ultimate extremities lead from the atrial apertures of the Ascidiozooids (fig. 3), and then open into larger canals, which again discharge into the large central spaces from which water and excrement are conducted through the excurrent orifices to the outer world. It will of course be borne in mind that these so-called "canals" are only irregular spaces excavated in the mass of the common test, and having nothing in the shape of an epithelial lining, although the cells in the test are very numerous, and often are so arranged as to present a deceptive resemblance to a flat epithelium.

As already mentioned, the incurrent orifices consist of the pores leading to the branchial apertures of the Ascidiozooids (fig. 3). These (i. e. the Ascidiozooids) are some little distance removed from the surface of the colony, so as to give rise to a veritable incurrent canal.

It is thus seen what a justifiable analogy may be drawn between these Ascidiozooids and the ciliated chambers of a sponge; in other words, between individuals on the one hand

and organs on the other. It is, however, necessary not to push this analogy too far.

It may have been noticed that so far we have not applied the term "common cloacal apertures" to the excurrent orifices, and we have intentionally abstained from doing so. In the Botryllidæ and Polyclinidæ, as has been long ago pointed out by Savigny, the cloacal apertures of the individuals belonging to a system which may be more or less regular, conspire together, sometimes in a very close manner, as in Botryllus or Circinalium, in other cases less closely, to form a true common cloacal aperture, which is capable of being opened and closed by muscular action.

In the Didemnidæ as a whole, and par excellence in our new Didemnid, this association of cloacal apertures does not occur. Here the cloacal apertures of the individual Ascidiozooids are perfectly distinct, and each opens independently into the canal-system in the way above described (see fig. 3).

Thus, while in the Botryllidæ, for example, the excurrent orifices are true common cloacal apertures, in the Didemnidæ they are distinctly not the same thing in the same sense, although they are possibly homologous structures.

This is why we have preferred to use the term "excurrent orifices."

3. Ascidiozooids.

As already indicated, the Ascidiozooids cannot be seen from the outside in a living colony; but in preserved specimens they appear as very numerous white specks, which are studded evenly all over the colony without any reference to a system or systems of distribution. In fig. 2 the black points immediately beneath the surface represent the Ascidiozooids, while the round bodies which lie deeper in the test are the larvæ.

On the structure of the individual Ascidiozooids we have nothing special to say, since they conform very closely to the Didemnid type. The most characteristic feature of all for the Ascidiozooids of the Didemnidæ is the single unpaired testis, round which the vas deferens is wound spirally.

This remarkable condition was first described and figured by Della Valle (5), and then insisted upon as being of classificatory importance by von Drasche (6).

As we have before said, we have not had the testis of our new genus under observation, so that it must be left doubtful at present whether the male gonad of this genus departs in any way from the usual condition of things in the other members of the family of the Didemnidæ.

The remaining important characters which the new genus possesses in common with the other Didemnidæ are—(*a*) the simple branchial sac, possessing only four rows of small oval stigmata; (*b*) long muscular processes of the mantle, which penetrate deeply into the test, and which are regarded as retractor muscles by von Drasche, who calls them "Ectodermfortsätze;"[1] (*c*) the absence of an oviduct. The ova float about in the body-cavity along with the blood-corpuscles, and as they grow in size they push the body-wall of the Ascidiozooid before them, and so give rise to a sac which gradually separates itself by constriction from the Ascidiozooid, and finally comes to lie freely in the test (fig. 4). This process has also been described by Della Valle (5, pp. 38, 39).

Tangential sections reveal the fact that the branchial apertures have an hexagonal form, corresponding to what von Drasche calls "Sechszähnig."

The budding of the Ascidiozooids takes place on the same plan as that called by Giard pyloric budding, and which has been well described by Della Valle (loc. cit., pp. 48—56). The detailed discussion of this process must, for reasons stated above, be left to a future occasion. By this method of budding, two different buds arise from the parent individual, and ultimately fuse together to form a new individual. One bud arises as an outgrowth from the œsophagus, and the other as

[1] The muscles in these processes are prolongations of the two strong dorsal muscles, which converge together at the base of the pharynx, and are then continued into the test as a single muscular band. A short hollow vascular ectodermic process can often be seen apparently springing from the body-cavity of the intestinal region of an Ascidiozooid.

an outgrowth of the parietal wall of the abdomen. We can see indications of this curious process in our preparations, more especially plainly the buds from the œsophageal region, but we have not been able to trace the further development of them.

The branchial tentacles of the Ascidiozooids are alternately long and short.

4. Larvæ.

The embryos having separated from the parent Ascidiozooid sink into the deeper parts of the test, and there develop into large tailed larvæ. This is also very characteristic for the Didemnidæ.

We wish to draw particular attention to the ring of twelve tentacle-like processes which surround the anterior end of the body of the larva, from which project the three adhering discs. These processes are hollow and communicate with the body-cavity, and contain very numerous blood-corpuscles.

They seem to be of very general occurrence in the tadpoles of the Didemnidæ. Ganin (2) called them "pelottenförmigen Anhänge," and states that among six species of Didemnum examined by him the number of these processes varied from four to fifteen or sixteen. Giard says (3, p. 610) that the Didemnidæ "ont des embryons pourvus de tubes stoloniaux généralement au nombre de 8, très-développés et prêts à former des blastozoïtes quand le jeune oozoïte sera fixé." In different places of his work Giard calls these processes indifferently "tubes stoloniaux," "tubes embryonnaires," and "tubes gemmifères." He figures them in the case of Leptoclinum gelatinosum. As a matter of fact, however, they have nothing to do with the budding, and Della Valle (loc. cit., p. 49) has rightly insisted that in the Didemnidæ the process of gemmation only commences after the larva has fixed itself. In spite of this von Drasche states wrongly that the embryos of the Didemnidæ show "rudimentäre Knospung." Herdman (7) has figured these processes in two species of Leptoclinum and in one species of Didemnum, but makes

not the slightest reference to them in the text, except in so far that he follows von Drasche in giving the appearance of "rudimentary embryonic blastogenesis" as a characteristic for the group. We will not deal with these tentacle-like processes any further at present, as one of us has recently been following their occurrence and relations in another group of Ascidians, namely, in the Styelinæ; and we will therefore defer the discussion of them. Suffice it to say that far from being connected with any budding process, they are, both in Didemnidæ and in the Styelinæ, transient larval appendages, which become reabsorbed in the course of development.

In the Botryllidæ, on the other hand, according to Metschnikoff ('Bull. de l'Acad. Imp. des Sciences de St. Petersburg,' t. xiii, 1869), they persist and give rise to the well-known vascular processes with swollen extremities which traverse the test of the adult colonies.

How the larvæ escape from their lodgment in the test is not quite clear. We may assume a process of absorption or possibly rupture, but neither can be asserted. The probability is that both occur. The larvæ can only sink into the depths of the test accompanied by a process of absorption, and when they are only separated from the central canal by a thin layer of test their movements could easily rupture that, and they could thus escape through the excurrent orifices.

5. Structure of Test—Spicules.

The deeper parts of the test contain numerous pigment concretions, and in the more superficial region there is a thin layer of extremely delicate calcareous spicules.

Although the presence of spicules is not an absolute feature of the Didemnidæ—since von Drasche has described two species of Didemnum, and Herdman one, in which spicules were absent; and, again, von Drasche has described a species of Diplosoma with spicules—yet combined with the other characters mentioned above, and especially with those belonging to the larvæ, the presence of spicules may be taken as a decisive feature in assigning the new genus to the family of

the Didemnidæ. The spicules form a distinct layer, and are fairly numerous. Their form is very various. A few varieties are shown in fig. 6, but the crenate form is perhaps the commonest.

They occur in special aggregations round the branchial apertures of the Ascidiozooids (fig. 5). They are seen to best advantage in sections which have been mounted unstained.[1]

At the surface the test consists to a very limited depth (fig. 3) almost entirely of large bladder-cells, which are usually rendered polygonal by mutual pressure, but when they contain crystals they are invariably perfectly round. Below the layer of bladder-cells the fusiform cells occur, and the bulk of the crystals are contained in a zone about equal in thickness to the layer of bladder-cells, but mainly scattered among the fusiform-cells. They occur more rarely in the bladder cells at the very surface.

But wherever the crystals—or, as they are usually called, calcareous spicules—occur, they are always found in large round bladder-cells; and, as Giard pointed out (p. 508), they are formed round the nucleus of the bladder-cell.

Lower down in the test the pigment concretions begin, and they seem also to be produced in similar large round cells of the test.

6. Systematic Position.

According to the classification of von Drasche (6), the Didemnidæ consist of two genera, namely, Didemnum and Leptoclinum,[2] the former having three and the latter four rows of branchial stigmata.[3] Leptoclinum, again, he splits up into

[1] It may just be noted that sections so mounted in benzole Canada balsam were of no use for observing the crystals, as the latter were very soon destroyed, probably through the influence of the impurities which frequently occur in benzole.

[2] Herdman, however, with good reason insists on maintaining the Eucœlium hospitiolum of Savigny, which has six rows of branchial stigmata.

[3] In von Drasche's scheme of classification the numbers are accidentally transposed. In the description of genera and species they are given correctly.

two sub-genera, viz. Leptoclinum proper, characterised by its thin encrusting cormi; and Didemnoides, which is qualified as follows:—"Fleischiger Cormus, in Polstern oder Knollen." Von Drasche describes and figures two species of Didemnoides, viz. D. macroophorum and D. resinaceum.

There can be very little doubt that we are right in allying our new genus with the Didemnoides of von Drasche, while the extraordinary habit of growth of our new form unquestionably calls for the formation of a new genus. As Della Valle (4) indicates, the thickness of 3 cm. is very great for a Didemnid, while our Didemnid attains a thickness of over 6 cm.[1] Perhaps the most striking feature of the new genus is the lateral compression which it exhibits (see fig. 2).

7. Summary.

Sarcodidemnoides misakiense, Oka and Willey.

Generic Characters.—Colony (or cormus) forming very thick lobose masses, laterally compressed; sessile, but not encrusting.

Excurrent orifices placed on the tips of the knoll-like prominences.

Ascidiozooids very numerous, not arranged in systems; branchial sac with four rows of stigmata; canal system complicated, differentiated into peripheral and central portions.

Specific Characters.—Atrial apertures of Ascidiozooids simple pores without teeth or languet; spicules fairly abundant, extremely delicate, confined to a thin layer near surface of test.

Test gelatinous, containing numerous bladder-cells, crystals, fusiform cells, and pigment concretions.

Stomach of Ascidiozooids vertically placed; surface of attachment of colony narrower than the free portion.

Colour, brilliant red.

Habitat.—Moroiso, Japan, between the tide-marks.

[1] Von Drasche (p. 32) mentions a species of Didemnum—D. tortuosum—which attains a thickness of 5 cm.

N.B.—Since the above was written I have seen for the first time the exhaustive work of Fernand Lahille, entitled 'Recherches sur les Tuniciers des côtes de France,' Toulouse, 1890. Lahille devotes considerable attention to what have been spoken of above as tentacle-like processes of the larva, figures them in many larvæ, and gives an excellent figure of the metamorphosing larva of Styela glomerata. He gives an opinion as to their significance which I cannot entirely endorse in the light of my own researches on the "Post-embryonic development of Styela," commenced last August at Plymouth. However, I hope to return to this question on a future occasion. Lahille raises an objection to von Drasche's genus Didemnoides on the ground that the thickness of the cormus is not an anatomical character, and that the distinction between thick and thin colonies is a purely subjective one. There is no doubt some truth in this; but the difference between a compound Ascidian which possesses, say, a very few spicules, and one which possesses none at all, would appear to be no more fundamental than that between a colony whose mode of growth resulted in the production of a fleshy mass and one which grew in the form of a thin leathery crust.

As stated above, von Drasche intends by Didemnoides a fleshy form of Leptoclinum, the test containing spicules, and the Ascidiozooids having four rows of stigmata in the branchial sac. Lahille, on the contrary, applies the name Didemnoides to those Didemnidæ which are characterised by the absence of spicules, and the possession of three rows of stigmata in the branchial sac.

The compound Ascidian which we have described above has spicules in the test, and four rows of stigmata in the branchial sac. But as it would be too absurd to call the new form "Sarcoleptoclinum," we shall persist in regarding the genus Didemnoides from the point of view of von Drasche.—A. W.

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EXPLANATION OF PLATES XVII and XVIII,

Illustrating Mr. Asajiro Oka's and Mr. Arthur Willey's paper "On a New Genus of Synascidians from Japan."

PLATE XVII.

Sarcodidemnoides misakiense, nov. gen. et spec.

View of colony, natural size and colour. Length 12 cm., height 6 cm. width about 3 c.m.

PLATE XVIII.

Fig. 1.—Diagrammatic view of the canal system of S. misakiense, showing peripheral and central portions of the system.

Fig. 2.—Transverse section through a whole colony to show the lateral compression and the narrow base. Dark points round margin are Ascidiozooids ; the round bodies lying deeper in test are embryos and larvæ.

Fig. 3.—Horizontal section through the branchial sac of an Ascidiozooid to show the position of the openings. The atrial opening is placed far back, a characteristic feature for the Didemnidæ. The surface-layer of bladder-cells in the test is shown on the right-hand side of the figure. Zeiss, DD, 2. *cl.* Cloaca, opening by cloacal aperture into peripheral canal.

Fig. 4.—Section showing an egg-cell in the body-cavity surrounded by blood-corpuscles.

Fig. 5.—Section through the branchial funnel of an Ascidiozooid to show the collar-like aggregation of calcareous spicules. Zeiss, E, 2, cam. luc.

Fig. 6.—Isolated spicules from the test. Zeiss, E, 4, cam. luc.

Fig. 7.—Tadpole of S. misakiense to show the ring of tentacle-like processes surrounding the three adhering papillæ. Zeiss, B, 2, cam. luc.